

ROBUST EXTRACTION AND MULTI-TECHNIQUE ANALYSIS OF MICROMETEOROIDS CAPTURED IN LOW EARTH ORBIT. A. J. Westphal¹, G. A. Graham², G. Bench³, S. Brennan⁴, K. Luening⁴, P. Pianetta⁴, L. P. Keller⁶, G. J. Flynn⁷, C. Snead¹, G. Domínguez¹, P. Grant³, S. Bajt⁵, J. P. Bradley² and A. L. Butterworth¹. ¹SSL, University of California at Berkeley, Berkeley, CA 94720-7450, USA, ²IGPP, LLNL, Livermore, CA 94551, USA, ³CAMS, LLNL, Livermore, CA 94551, USA, ⁴SSRL, SLAC, Stanford, CA 94025, USA, ⁵PAT, LLNL, Livermore, CA 94551, USA, ⁶Code SR, NASA/JSC, Houston, TX 77058, ⁷Dept. Physics, SUNY, Plattsburgh, NY 12901, 3SSL, U. C., Berkeley, Berkeley, CA 94720

Introduction: The use of low-density silica aerogel as the primary capture cell technology for the NASA Discovery mission *Stardust* to Comet Wild-2 [1] is a strong motivation for researchers within the Meteoritics community to develop techniques to handle this material. The unique properties of silica aerogel allow dust particles to be captured at hypervelocity speeds and to remain partially intact. The same unique properties present difficulties in the preparation of particles for analysis. Using tools borrowed from microbiologists, we have developed techniques for robustly extracting captured hypervelocity dust particles and their residues from aerogel collectors[2-3]. It is important not only to refine these extraction techniques but also to develop protocols for analyzing the captured particles. Since *Stardust* does not return material to Earth until 2006, researchers must either analyze particles that are impacted in the laboratory using light-gas-gun facilities [e.g. 4] or examine aerogel collectors that have been exposed in low-Earth orbit (LEO) [5]. While there are certainly benefits in laboratory shots, i.e. accelerating known compositions of projectiles into aerogel, the LEO capture particles offer the opportunity to investigate real particles captured under real conditions

Experimental: The aerogel collectors used in this research are part of the NASA Orbital Debris Collection Experiment that was exposed on the MIR Space Station for 18 months [5]. We have developed the capability at the UCB Space Sciences Laboratory to extract tiny volumes of aerogel that completely contain each impact event, and to mount them on micromachined fixtures so that they can be analyzed with no interfering support (Fig.1). These aerogel “keystones” simultaneously bring the terminal particle and the particle track to within 10 μ m (15 g cm^{-2}) of the nearest aerogel surface. The extracted aerogel wedges containing both the impact tracks and the captured particles have been characterized using the synchrotron total external reflection X-ray fluorescence (TXRF) microprobe at SSRL, the Nuclear Microprobe at LLNL, synchrotron infrared microscopy at the ALS facility at LBL and the NSLS at BNL, and the Total Reflection X-ray Fluorescence (TXRF) facility at SLAC.

Discussion: Most of the techniques that have been applied on the extracted wedges are essentially non-destructive or have limited detrimental effects on the particles. An exception may be the alteration of hydrogenous material during PIXE, RBS or PESA analysis with the Nuclear Microprobe. While it is important assess the suitability of the various analytical techniques, the particles captured in LEO offer an opportunity to examine material that has not been subjected to selection and modification processes that occur during atmospheric transit by the particles terrestrial repositories of cosmic dust. Of course the captured particle may have undergone alteration during hypervelocity capture.

From the X-ray maps acquired using proton induced X-ray emission it is clearly possible to identify fine Fe rich particulate material on the sub-micron scale that has deposited on the walls of impact track (Fig. 2). However the identification of light elements from the data acquired from proton elastic scattering analysis and proton backscattering analysis would suggest that while the particles may fragment during hypervelocity capture the volatile elemental chemistries are not lost. This is clearly important when it comes to the analysis of any organic material.

We are also developing techniques for extracting dust particles from the impact region within keystones, either at the terminus or along the impact track, using both mechanical extraction techniques and focused ion beam (FIB) milling.

References: [1] Brownlee D. E. et al (2000) *Meteorit. Planet. Sci.*, 35, A35. [2] Westphal A. J. et al. (2002) *Meteorit. Planet. Sci.*, 37, 855-865. [3] Westphal A. J. et al (2003) LPS XXXIV, #1826. [4] Burchell, M. J. et al (2001) *Meteorit. Planet. Sci.*, 36, 209-221. [5] Horz F. et al. (2000) *Icarus*, 147, 559-579.

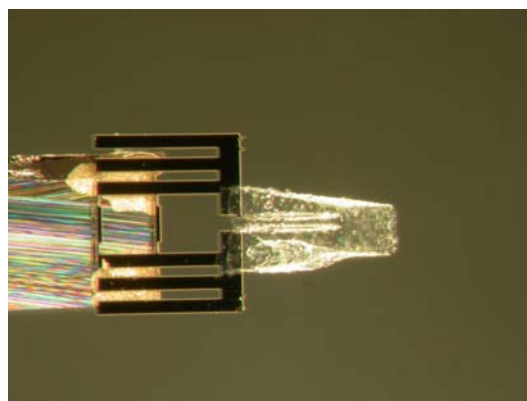


Figure 1: An extracted aerogel “keystone” completely containing a hypervelocity dust impact.

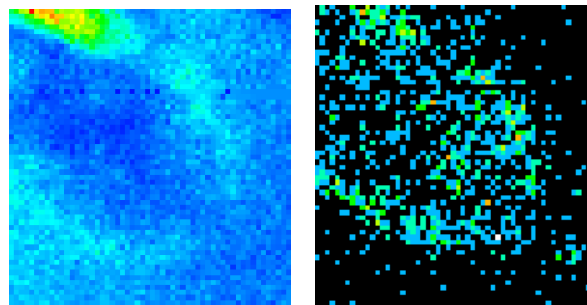


Figure 2: PIXE Si (left) and Fe (right) maps of an impact event from the ODCE collector.